Rec'd PCT/PTO 28 APR 2005
10/533039

LWC paper and method for making the same

The invention relates to LWC paper and its production.

An object of the invention is to improve the quality of a paper product, especially LWC paper, and the economy of producing the same.

Paper is required to have a certain surface quality for ensuring a desired gloss and print quality, a low transparency and a sufficient stiffness and tear resistance. Additionally, since paper is produced in large quantities in a paper mill, the efficient use of raw material is important. These demands are somewhat contradictory to each other. Paper can be provided with a sufficient gloss by calendering the paper by compressing it in a nip, often moistened and heated in a certain manner. The surface fibers and coating of paper are preferably pressed smooth by this compression, yet without compacting the middle layer of paper. The compaction of a middle layer undermines the stiffness of paper and reduces tear resistance. At the same time, the transparency of paper increases. This compaction of a middle layer is often referred to as a loss of bulk. In this case, bulk is understood as being the inverse value of density and a loss thereof is thus equal to a densifying compaction of paper or board.

Since the process of making paper is highly raw material intensive, even a minor saving in raw material provides a major advantage over competitors. In this respect, a saving of just one percent can be considered a major competitive edge and the investment restitution time is short. Saving raw material is also desirable for environmental reasons. By virtue of a paper grade of lower weight, the beneficial multiplicative effects of the paper of this invention cover the product's entire life span, the reduced consumption of raw material resulting in a lighter product which ultimately creates savings also in shipping operations and in the way of a reduced amount of waste.

The improved bulk and opacity do not cause the consumer any practical adversities.

A machine calender is often used together with other calenders, the machine calender referring to a hard calender with no elasticity in its rolls. The use of a machine calender as the sole surface treatment method is not advisable. A soft calender refers to a soft-nip calender, wherein the calender roll has a surface which is elastic, the surface having possibly a hardness in the same order as the surface hardness of wood, yet being elastic.

It is an object of this invention to provide a flat printing surface, a high gloss and stiffness in printing paper with a lesser-than-before consumption of material and to avoid bottlenecks as well as to improve runnability with a method of the invention. Generally, the pretreatment of a paper surface prior to a coating process is performed with a machine calender and the finishing treatment with a supercalender. The function of a machine calender is to provide the web with a uniform thickness profile. After machine calendering, paper is coated and final calendering is usually performed with a supercalender. The coating method is typically blade coating or film coating.

The quality values of thus produced offset LWC printing paper are within the following range:

Bulk	0,90-1,1 cm^3/g
PPS-s10 roughness	0,8-1,6 µm
Gloss	50-70%

According to the invention, printing paper is treated with a long-nip calender after a coating process in order to upgrade the paper qualities over what is known before and, in addition, the production runnability is improved and the production method is not subject to a speed restraint the same way as a

supercalender. A long-nip calender suitable for making paper of the invention has been described for example in the Applicant's earlier patent US6164198.

A printing paper product of the invention is characterized by what is set forth in the characterizing clause of claim 1.

A calender suitable for the surface treatment of paper of the invention is provided with a fixed support element, around which is a tubular jacket. A heated counter element is disposed on the other side of the tubular jacket from the support element, such that a web passes through between said counter element and the tubular jacket. The fixed support element is provided with load elements, pressing the jacket against the heated counter element and thereby enabling a calendering process between the jacket and the counter element. The jacket has its opposite ends secured to end walls mounted rotatably relative to the support element, the rotary motion of the end walls being delivered by a separate drive motor, which is independent of a motion of the fiber web in order to avoid overheating of the jacket.

A method of the invention for conditioning the surface of coated or uncoated paper with a surface conditioning device is in turn characterized by what is set forth in the characterizing clause of claim 13. The method comprises feeding a fiber web through a long nip established by a roll and a counter-roll, the former being in the form of a tubular-shaped flexible jacket. Across the extent of the nip the jacket deflects or bends and thereby presses into contact with the counter-roll over a long stretch. The paper treated with the method is lighter than currently available paper grades, while stiffness and surface properties are equal to those of currently available papers.

The solution enables a running speed substantially higher than what is accomplished with a supercalender. In addition, the runnability is better, which also contributes to improved quality and reduces waste.

Web speed in the calender may be higher than 600m/min, preferably higher than 800m/min, and still more preferably 1000 m/min, and even as high as about 4000 m/min. Thus, the calender neither restricts the speed of a paper machine nor is there a need for several calenders in parallel. The above-mentioned heated roll has a temperature of 150-350°C, preferably higher than 170°C, most preferably about 200-250°C. Linear pressure in the nip is within the range of 100-500 kN/m, preferably less than 400, most preferably about 320-380 kN/m. Maximum pressure in the nip is 3-15 MPa, preferably less than 13 MPa, most preferably about 8-12 MPa.

A calender suitable for the surface treatment of paper of the invention will now be described with reference to the figures.

Fig. 1 is a sectional view of a long-nip calender, provided with an extended nip between a shoe calender and a counter-roll.

Fig. 1A is a partial enlargement of fig. 1.

Fig. 2A is a partial sectional view of the device shown in fig. 1, along the roll axis and depicting a drive mechanism.

Fig. 2B shows the operation of press shoes in a longitudinal section.

In fig. 1, a paper 80 travels through an extended and heated nip 1. The nip 1 is established by means of an enclosed shoe roll 10 present under the web 80. Above the web 80 is a heatable counter-roll 22. The enclosed shoe roll comprises a flexible jacket 12 impervious to liquid. The jacket consists for example of fiber-reinforced polyurethane. A stationary fixed support element 14 carries at least one load shoe 18. Between the load shoe 18 and the support element is an actuator 20, such as a hydraulic cylinder, for urging

the concave load shoe 18 and thereby also the flexible jacket 12 against the counter-roll 22. Thus, the jacket 12 is forced out of its normal unloaded position 11 in a direction away from the center of the enclosed shoe roll. The jacket 12 is fastened at both ends thereof to end walls 24, 26, thus creating a sealed compartment 13 (see fig. 2). As also shown in fig. 1, at least one detector device 99 is mounted in communication with the web 80 for detecting web breaks. The detector device 99 is connected to a control device 98 for controlling the operation of a calendering process depending on whether the web is broken or not.

As shown in fig. 1, the heatable counter-roll 22 is accompanied by a disengagement mechanism, comprising a lever 95 pivotable by means of a hydraulic cylinder assembly 94 and provided with a pivot point 96 for pivoting the lever thereon. The disengagement mechanism presses the counter-roll 22 to an engagement with the nip 1 and disengages it from the nip 1. Between the load shoe 18 and the jacket 12 is supplied pressurized oil, which develops a hydrostatic pressure throughout the nip and presses the jacket to an engagement with the counter-roll 22 over the entire extent of the nip 1. At the same time, the oil protects the jacket from being damaged by lumps and a temperature rise.

In fig. 2A, it is shown that the end walls 24, 26 are rotatably mounted on stub shafts 16, 17 of the support element 14. (The end walls are preferably not integral but divided into a static part and a rotating part, as shown in fig. 2B). On one end of the stub shaft, a cylindrical shaft 32 is arranged rotatably via bearings 34. A support column 36 is arranged to the cylindrical shaft via self-aligning bearings 38, which allow spherical movement to allow the deformation/bending of the support element 14 in response to a heavy load. One of the end walls 24 is fixedly attached to the cylindrical shaft. A drive transmission 40, in the present embodiment a cog wheel, is fixedly attached to the cylindrical shaft outside the end wall. The cog wheel is connected to a

transmission 42 and in turn a drive 44. A cog wheel 46 is fixedly attached to the cylindrical shaft inside the end wall. A drive shaft 48 is arranged inside the jacket and parallel to the support element 14. The drive shaft 48 is supported by bearings 50 arranged in bearing houses 52 attached to the support element. At each end of the drive shaft, cog wheels 54 are arranged. Preferably these cog wheels have a prolonged toothed portion to allow axial movement of the intermeshing cog wheel which is attached to the end wall. A further cog wheel 56 is fixedly attached to the second end wall 26 inside the jacket. Both cog wheels inside the jacket mesh with the corresponding cog wheel on the drive shaft. The second end wall 26 is rotatably arranged on the second stub shaft 17. The second stub shaft is in turn fixedly attached to a second support column 58.

The operation proceeds as follows. During normal operation, the driven heated roll 22 is in interaction with the fiber web and the flexible jacket 12 by means of a desired pressure being exerted by the load shoe 18, thereby causing a friction based drive of both the fiber web and the flexible jacket. Accordingly, during normal operation, the forces exerted in the nip provide for rotation of the enclosed shoe roll.

Only in specific occasions, it will normally be desirable to operate the independent drive of the enclosed shoe roll 10, for example when starting up the calender. If the calender should be started without first speeding up the flexible jacket 12, this would inevitably cause damage to the flexible jacket due to overheating. Furthermore, it would also be deteriorating for the fiber web, since at the moment of start it would develop exceptional tension forces in the fiber web. Accordingly, the independent drive arrangement of the enclosed shoe roll is to be used for instance at the start-up of the calendering surface. At the start, the nip gap is not closed, but the roll 22 has been moved out of contact with the nip 1. Before moving the heated counter-roll 22 into the nip, the drive arrangement 44 of the enclosed shoe

roll 10 is activated to accelerate the first end wall 24 via transmissions. The rotation of the end wall causes the inner first cog wheel 46 to rotate, and subsequently the drive shaft 48. The drive shaft transmits the rotation to the second end wall 26 via the second inner cog wheel 56. The both end walls are thus accelerated and rotate at the same speed until a desired peripheral speed is obtained, which is normally equal to the speed of the fiber web. The nip is closed by activating the hydraulic piston 94 to pivot the lever 95 and thereby moving the counter-roll 22 into the nip and subsequently the load shoe 18 is urged against the heated roll 22 by means of its actuators 20. Once the calender functions in the desired manner, the drive arrangement of the enclosed shoe roll can be deactivated and the press roll driven in a conventional manner by means of friction within the nip 1.

In fig. 2B there is shown an alternative embodiment of the drive arrangement for an enclosed shoe roll. This embodiment uses friction for the transmission of rotational forces.

Fig. 2B also shows a more preferred design of arranging the support element and the end walls. The end walls are divided into an inner part 24A; 26A connected non-rotatably to the support element 14, a rotational part 24B; 26B, and a bearing assembly 24C; 26C therebetween. The support element 14 is at each end thereof arranged with self-aligning bearings 23, 25 to allow a deflection of the support element 14.

In the figure there is shown a drive 44 having a shaft 19B. On the shaft 19B is mounted a disc 19 having a rubber layer at its peripheral end 19A. The outer ends of the flexible jacket 12 are fixedly attached between an annular ring 15, acting as a replaceable force transmitting device, and the periphery of each end wall. The ring 15 is fixedly attached to the end wall. On the inside of the rotational part 24B, 26B of each end wall there is fixedly attached a cog wheel 46, 56. The drive arrangement 44, 19 is movable in

and out of contact with the force transmitting device 15. When it is desired to accelerate the enclosed shoe roll 10, the drive arrangement is moved such that the rubber layer 19A comes into frictional engagement with the force transmitting device 15. The cog wheel 46 and the drive shaft 48 transmit the rotation of the end wall 24 to the other end wall 26 by means of the cog wheels 54, 55 and 56, which at the same time function as a synchronizing device. Hence, both end walls 24, 26 are operated as described in reference to fig. 2A. Fig. 2B further illustrates in a schematic view one preferred functional embodiment of the load shoe 18. As a rule, the load shoe 18 is not disposed diametrally relative to the drive shaft, but perpendicularly as in fig. 2A.

Tests indicated that, in test batches manufactured by means of a long-nip calender as described above, the batches of paper could be provided with a ratio of bulk and smoothness better than in currently available grades of paper. Thus, according to measurements, the object of the invention is well fulfilled.

Shoe calenders can be driven at remarkably high speeds and, furthermore, by the application of an elevated temperature, e.g. about 250°C, and by taking into account a long dwell time in the calendering zone, the resulting gloss finish will be equal to what is achieved in a slower solution using a supercalender. In addition, the paper is provided with improved bulk. In addition to aspects contributing directly to the quality of paper, the results include savings of production space in a mill, the elimination of a production limiting supercalender, and the provision of a more manageable, more easily controlled system.

In view of producing paper of the invention, there is used a non-contact coating process prior to glazing final calendering. Suitable coating methods include for example curtain or spray coating.

The quality values of thus produced paper in pilot conditions were as follows:

Bulk	1,15-1,3 cm^3/g
PPS-s10 roughness	1,0-1,5 µm
Gloss	40-50%

Compared with prior known grades, the obtained paper is higher in bulk and smooth and, in addition, the production method has a production capacity which is higher that what is achieved by a single supercalender. The method provides saving in paper manufacture and improves economy. Especially, the increase of capacity is possible with the same paper machine by on-line calendering. When compared to using several supercalenders, more space can be saved in the case of a new mill or the operation of an old mill can be rationalized. The provision of higher bulk represents a direct saving in terms of the amount of material and energy needed for production and, likewise, lighter printing paper saves energy over its service life and ultimately produces less waste to be handled.